

CLAIMS

We claim:

- 1 1. A method for determining a submarine geographic position, the method comprising the steps
2 of:
 - 3 a) launching a radio navigation-enabled buoy and recording a launch time and a DRNS
4 geographic position estimate^{of said buoy}, wherein said DRNS geographic position estimate is
5 determined by a DRNS;
 - 6 b) recording a buoy breach time and searching for radio navigation signals^{of said buoy}, wherein said
7 buoy breach time is subsequent to said launch time;
 - 8 c) recording a radio navigation position acquisition time and an initial radio navigation
9 position^{of said buoy}, wherein said subsequent^{acquisition} time is subsequent to said buoy breach time;
 - 10 d) recording a subsequent radio navigation position^{of said buoy} and a subsequent time, wherein said
11 subsequent time is subsequent to said radio navigation position acquisition time;
 - 12 e) determining a DRNS correction factor using a DRNS position error, a buoy drift^{the recorded}, radio
13 navigation^{positions of said buoy} position data and DRNS position data^{of said buoy};
 - 14 f) estimating said submarine geographic position using said DRNS correction factor and
15 said DRNS geographic position estimate.
- 1 2. The method of Claim 1, wherein said radio navigation-enabled buoy comprises a GPS-
2 enabled buoy.
- 1 3. The method of Claim 1, wherein said DRNS position error is determined by extrapolating a
2 radio navigation/drift estimated geographic position of said radio navigation-enabled buoy at
3 said buoy breach time using a radio navigation/drift position and said buoy drift and
4 comparing said radio navigation/drift estimated geographic position of said radio navigation-
5 enabled buoy at said buoy launch time to a launch time^{of said} DRNS geographic position estimate
6 of said submarine at said buoy launch time.
- 1 4. The method of Claim 1, wherein said DRNS is an INS.

1 5. The method of Claim 1, wherein said determining a DRNS correction factor ~~using DRNS~~
2 ~~position error, buoy drift, radio navigation position data and DRNS position data~~ comprises
3 the following sub-steps:

4 i) extrapolating a radio navigation/drift estimated geographic position of said radio
5 navigation-enabled buoy at said buoy breach time ^{said recorded} using radio navigation positions
6 ~~data~~ and said buoy drift;

7 ii) comparing said radio navigation/drift estimated geographic position of said radio
8 navigation-enabled buoy at said buoy breach time to a DRNS estimated geographic
9 position of said submarine at said buoy launch time;

10 iii) determining said DRNS correction factor from said DRNS position error.

1 6. The method of Claim 5, wherein said extrapolating a radio navigation/drift estimated
2 geographic position of said radio navigation-enabled buoy at said buoy breach time
3 comprises the following sub-steps:

4 (1) determining said buoy drift by comparing said initial radio navigation position
5 data to said subsequent radio navigation position and said radio navigation
6 position acquisition time to said subsequent time;

7 (2) extrapolating ^{said} radio navigation/drift estimated geographic position of said radio
8 navigation-enabled buoy at said buoy breach time using ^{said recorded} radio navigation positions
9 ~~data~~ and said buoy drift.

1 7. The method of Claim 5, wherein said extrapolating a radio navigation/drift estimated
2 geographic position of said radio navigation-enabled buoy at said buoy breach time by the
3 following sub-steps:

4 (1) determining a latitude displacement and a longitude displacement by multiplying
5 a latitude drift velocity by an elapsed time and a longitude drift velocity by said
6 elapsed time, wherein said elapsed time equals a first event time subtracted from a
7 second event time;

8 (2) subtracting said latitude displacement and said longitude displacement to a
9 navigation position ^{of said buoy} associated with said second event time.

1 8. The method of Claim 7, wherein said first event time is said buoy breach time, and wherein
2 said second event time is said radio navigation position acquisition time, and wherein said
3 second event time is subsequent to said first event time.

1 9. The method of Claim 1, wherein said buoy drift is represented by latitude/longitude
2 displacement over time.

1 10. The method of Claim 1, wherein said method is performed by a processing means.

1 11. The method of Claim 10, wherein said processing means includes a submarine navigation
2 computer.

1 12. The method of Claim 10, wherein said processing means includes a buoy computer and a
2 navigation computer.

1 13. A submarine launched radio navigation buoy system, comprising:

2 a) a submarine launched radio navigation buoy, capable of:

3 i) launching from a submerged submarine;

4 ii) obtaining a plurality of radio navigation positions^{of said buoy} from radio navigation RF signals
5 and a plurality of corresponding event times;

6 iii) transmitting said plurality of corresponding event times and said plurality of radio
7 navigation positions;

8 b) a processing means, operatively coupled to said submarine launched radio navigation
9 buoy, capable of:

10 i) receiving said plurality of corresponding event times and said plurality of radio
11 navigation positions^{of said buoy};

12 ii) determining a DRNS correction factor using a DRNS position error, a buoy drift,
13 ^{said} radio navigation ^{positions} ~~position data~~ and DRNS position data^{of said buoy};

14 iii) estimating a submarine geographic position using said DRNS correction factor and a
15 DRNS geographic position^{of said buoy};

1 14. The submarine launched radio navigation buoy system of Claim 13, wherein said submarine
2 launched radio navigation buoy is a GPS-enabled buoy.

1 15. The submarine launched radio navigation buoy system of Claim 13, wherein ~~said processing-~~
2 ~~means determines~~ said DRNS position error is determined by extrapolating a radio
3 navigation/drift estimated geographic position of said radio navigation-enabled buoy at said
4 buoy breach time using a radio navigation/drift position ^{of said buoy} and said buoy drift and comparing
5 said radio navigation/drift estimated geographic position of said radio navigation-enabled
6 buoy at said buoy breach time to a DRNS estimated geographic position of said submarine at
7 said buoy launch time.

1 16. The submarine launched radio navigation buoy system of Claim 13, wherein said processing
2 means determines ^{said} DRNS correction factor using ~~DRNS position error, buoy drift, radio~~
3 ~~navigation position data and DRNS position data~~ comprises the following sub-steps:

4 i) extrapolating a radio navigation/drift estimated geographic position of said radio
5 navigation-enabled buoy at said buoy breach time using ^{said} radio navigation positions
6 ~~data~~ and said buoy drift;

7 ii) comparing said radio navigation/drift estimated geographic position of said radio
8 navigation-enabled buoy at said buoy breach time to a DRNS estimated geographic
9 position of said submarine at said buoy launch time;

10 iii) determining said DRNS correction factor from said DRNS position error.

1 17. The submarine launched radio navigation buoy system of Claim 16, wherein said processing
2 means extrapolates a radio navigation/drift estimated geographic position of said radio
3 navigation-enabled buoy at said buoy breach time comprises the following sub-steps:

4 (1) determining said buoy drift by comparing said initial radio navigation position
5 data to said subsequent radio navigation position and said radio navigation
6 position acquisition time to said subsequent time;

7 (2) extrapolating a radio navigation/drift estimated geographic position of said radio
8 navigation-enabled buoy at said buoy breach time using radio navigation position
9 data and said buoy drift.

1 18. The submarine launched radio navigation buoy system of Claim 16, wherein said processing
2 means extrapolates ^{said} radio navigation/drift estimated geographic position of said radio
3 navigation-enabled buoy at said buoy breach time by the following sub-steps:

4 (1) determining a latitude displacement and a longitude displacement by multiplying
5 a latitude drift velocity by an elapsed time and a longitude drift velocity by said
6 elapsed time, wherein said elapsed time equals a first event time subtracted from a
7 second event time;

8 (2) subtracting said latitude displacement and said longitude displacement to a
9 navigation position associated with said second event time.

1 19. A submarine launched radio navigation buoy system, comprising:

2 a) means for launching a radio navigation-enabled buoy;

3 b) means for recording a launch time, a DRNS geographic position estimate ^{of said buoy}, a buoy breach
4 time, a radio navigation position acquisition time and a subsequent time, wherein said
5 subsequent time is subsequent to said radio navigation position acquisition time, which is
6 subsequent to said buoy breach time, which is subsequent to said launch time;

7 c) means for searching for and receiving radio navigation signals ^{of said buoy};

8 d) means for recording an initial radio navigation position ^{of said buoy} and a subsequent radio navigation
9 position ^{of said buoy};

10 e) means for determining a DRNS correction factor using a DRNS position error, a buoy
11 drift ^{the recorded}, radio navigation ^{positions of said buoy} position data and DRNS position data ^{of said buoy};

12 f) means for estimating said submarine geographic position using said DRNS correction
13 factor and a DRNS geographic position ^{of said buoy};

1 20. A method for determining a submarine geographic position, the method comprising the steps
2 of:

3 a) launching a radio navigation-enabled buoy and recording a launch time and a DRNS
4 geographic position estimate ^{of said buoy}, wherein said DRNS geographic position estimate is
5 determined by a DRNS;

- 6 b) recording a buoy breach time and searching for radio navigation signals^{of said buoy}, wherein said
7 buoy breach time is subsequent to said launch time;
- 8 c) recording a radio navigation position acquisition time and an initial radio navigation
9 position^{of said buoy}, wherein said ^{acquisition} subsequent time is subsequent to said buoy breach time;
- 10 d) determining a DRNS correction factor using a DRNS position error, a buoy drift^{said recorded initial}, radio
11 navigation position ~~data~~ and DRNS position data^{of said buoy}, wherein said buoy drift is received
12 from a DRNS associated with said radio navigation-enabled buoy;
- 13 e) estimating said submarine geographic position using said DRNS correction factor and
14 said DRNS geographic position estimate.

1 21. A method for determining a submarine geographic position, the method comprising the steps
2 of:

- 3 a) launching a radio navigation-enabled buoy and recording a launch time and a DRNS
4 geographic position estimate^{of said buoy}, wherein said DRNS geographic position estimate is
5 determined by a DRNS;
- 6 b) recording a buoy breach time and searching for radio navigation signals^{of said buoy}, wherein said
7 buoy breach time is subsequent to said launch time;
- 8 c) recording a radio navigation position acquisition time and an initial radio navigation
9 position^{of said buoy}, wherein said ^{acquisition} subsequent time is subsequent to said buoy breach time;
- 10 d) determining a DRNS correction factor using a DRNS position error, a buoy drift^{said recorded initial}, radio
11 navigation position ~~data~~ and DRNS position data^{of said buoy}, wherein said buoy drift is received
12 from a sonar system capable of tracking said radio navigation-enabled buoy;
- 13 e) estimating said submarine geographic position using said DRNS correction factor and
14 said DRNS geographic position estimate.